Vacuum **FREEZE-DRYING**

- Industrial Production Plants with Daily Throughputs Ranging from 500 kg to 60 tons of Fresh Product per Unit

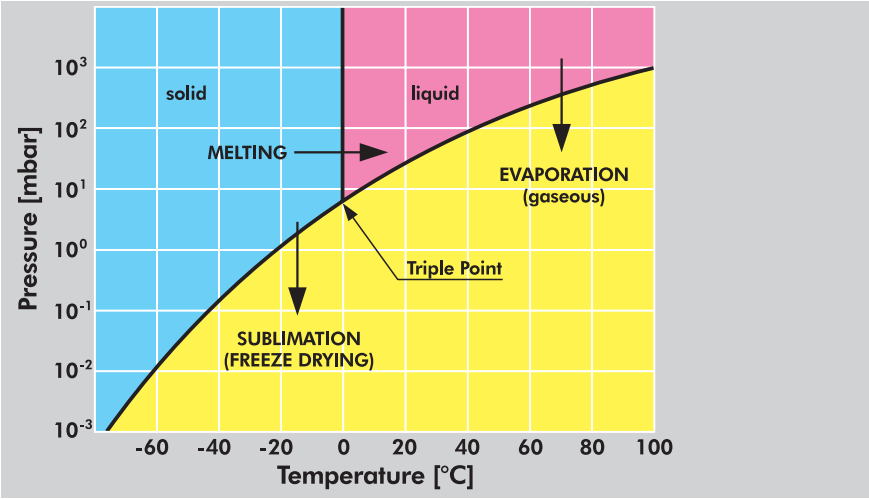
Industrial Freeze-Drying

Freeze-drying is used to preserve products containing water or solvents. Good preservation of fragrances, flavorings and ingredients with nutritional value is crucial in the foodstuff industry. With proper packaging and storage, freeze-dried products can be stored for a very long time without any appreciable loss of quality even at room temperature. Weight reduction will be up to 92%. Owing to their extremely large internal surface area, freeze-dried products have an optimal capacity to take up water again (reconstitution, rehydration). ALD industrial freeze-drying systems offer the best capabilities with respect to performance, versatility and product quality and lower heating temperatures by contact heating, hence a lower final temperature of the product and better flavor retention. Further-more they have more sublimation power per m^2 of area.

Applications of Freeze-Drying:

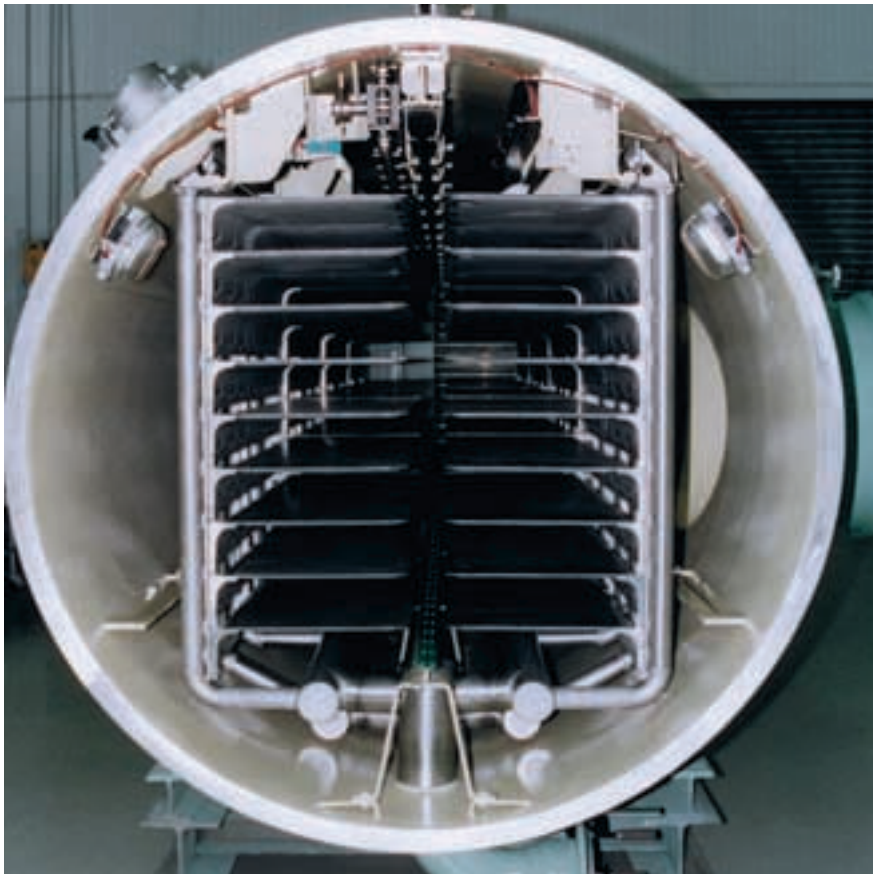
- Instant coffee and tea;
- Drying of meat and meat products, poultry, fish and shellfish, fruits and vegetables;
- Dairy products such as starter cultures for yogurt and cheese production;
- Freeze-drying of coloring pigments;
- Production of starting materials having little agglomeration for use in the manufacture of complex sintered ceramic materials.

The main application for freeze-drying results from the remarkable advantages of the final product with respect to the conservation of volatile aromatics, heat-sensitive ingredients, color, taste, original shape, texture and nutritional value, as well as quick rehydration before use.



Phase diagram for water

Standard freeze-drying tunnel section



The Principles of Freeze-Drying

At atmospheric pressure (approx. 1,000 mbar) water can have three physical states

- Solid;
- Liquid;
- Gaseous.

Below the triple-point (for pure water: 6.1 mbar at 0°C), only the solid and the gaseous states exist.

The principle of freeze/sublimation-drying is based on this physical fact. The ice in the product is directly converted into water vapor (without passing through the "fluid state") if the ambient partial water vapor pressure is lower than the partial pressure of the ice at its relevant temperature.

The freeze-drying process is divided into two different physical process steps. Step one is the freezing of the material below its solidification temperature and step two removes the ice or solvent crystals at very low temperatures.

The Freezing Process

The freezing process has a great influence on the quality of the finished product and the time that will be required to dry the material.
For continuously operating freeze-drying installations with high throughputs the most familar freezing systems will be continuous blast air freezing belts. In addition, fluidised bed systems, freezing channels or chambers will be used.

Continuous freeze-drying system with up to 60 tons of fresh product per day per unit

For freezing of liquids, especially coffee extract, automatic freezing belts are used. Different temperature zones, variable velocity of the belt and adjustable thickness of the product layer permit optimized freezing conditions adapted to the requirements of the different products.

Granulation

Frozen liquids, especially coffee extract, are granulated and classified to the desired granule sizes in a cold room at very low ambient temperatures. The frozen granules are collected in a buffer store and then fed into special drying trays by an automatic filling device.

Freeze-Drying

The drying process is carried out in a vacuum chamber at pressures that are lower than the water vapour pressure of the frozen products at their solidification temperature. The necessary heat to effect and accelerate sublimation is supplied from an external source.

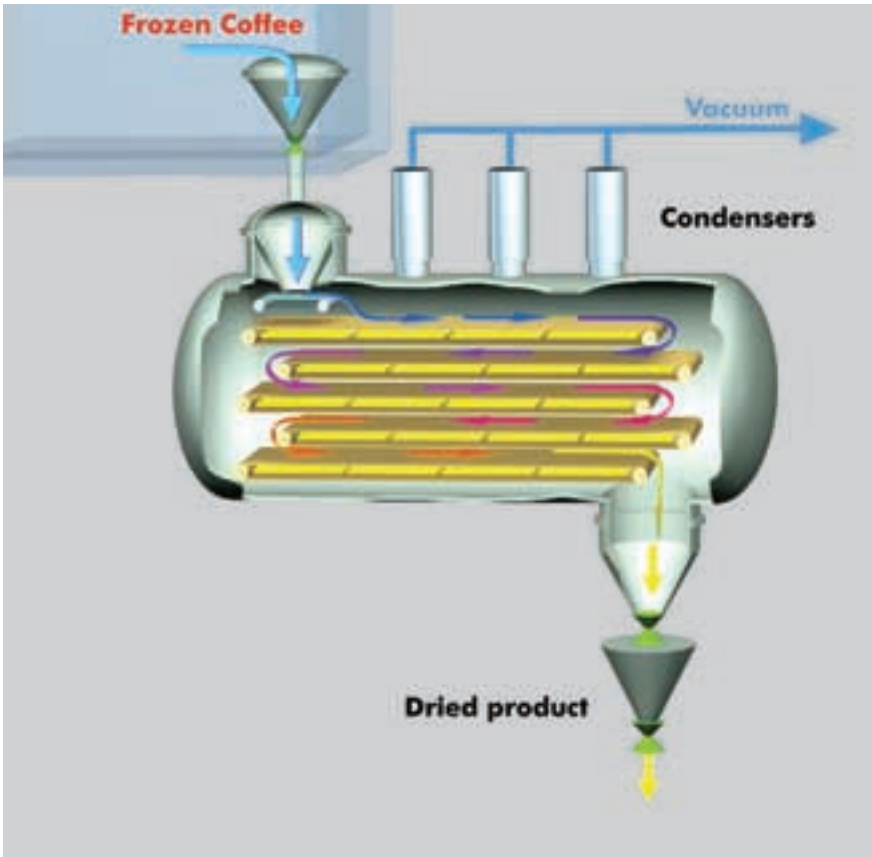
The ALD delivery program comprises large industrial production plants with throughputs ranging from 500 kg to 60 tons of fresh product per day and plants in continuous and discontinuous operation.

In static freeze-drying, carriers with the filled drying trays are transported into the freeze-drying tunnel. During the drying process, the carriers with the drying trays move automatically through different temperature zones. The entry and exit operation is realized by vacuum lock systems enabling the continuous operation of freeze-drying.

In addition to the known freeze-drying method with trays (static freeze-drying) ALD offers so-called "Dynamic Freeze-Drying Installations". This drying method is used for fluid/free-flowing products. In this "trayless systems", the products are in direct contact with the heating surface. The frozen and granulated product is brought into the sublimation/drying tunnel by a special lock device.

Inside the drying tunnel, the product is uniformly distributed by a special distribution device to the first belt of the belt transport system. A thin product layer and some intermix/turn-around of the product permits

Schematic of the belt system for dynamic freeze-drying



a very short drying time and thereby an excellent quality of the dried product (flavor retention) is attainable.

The necessary heat for the sublimation of water is conveyed through direct contact between the synthetic belts and the heating plates mounted below. Different adjustable temperature zones allow an optimized temperature profile in order to perform the different requirements of the pre-drying, main drying and after-drying sections.

At the end of the belt transport system, the freeze-dried product passes an outlet vacuum lock and is filled into storage containers.

Condenser coil for automatic defrosting

Condenser Vacuum System

The most efficient water vapour pump is a surface at low temperature, if the temperature is lower than the freezing temperature corresponding to the particular pressure. The size of the condenser surface and the area of the connecting tube to the sublimation tunnel determine the maximum suction capacity (load of water vapor) as well as the acceptable ice capacity. The temperature at the surface of the condenser determines the pressure of the condensable vapours during freeze-drying in the chamber.

All condenser systems are equipped with automatic defrosting systems whereby defrosting will be realized under vacuum conditions for efficient and quick defrosting. In order to maintain a continuous operation process various condensers are connected to the individual tunnel sections.

The ice condenser system collects most of the condensable vapours (mainly water vapour). For removal of non-condensables i.e., inert gases, however, vacuum pump sets are installed.

Process Control

Regardless of whether the system works continuously or non-continuously, the entire process is controlled and monitored by the PLC according to the production process requirements.

Refrigeration Plant

In industrial freeze-drying installations, great refrigeration capacities must be achieved at low evaporation temperatures of less than minus 40 °C down to minus 60 °C.

Ammonia absorption installations and compressor-type installations may be used for the generation of the necessary refrigeration capacity. The final/adequate choice of the refrigeration system depends on various factors such as cost of electrical energy and heavy oil, process, operation and product parameters.

Vacuum pump system of a continuous freeze-drying plant

Processing Lines

ALD Vacuum Technologies AG can also design, engineer and construct complete processing lines for pre- and post-process treatment of products like freeze-dried coffee, fruits and vegetables, etc.

Installation of an ALD industrial freeze-drying unit